Air Traffic Controllers and Real-time Simulation: A Powerful Combination

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Introduction

A key to successful human-in-the-loop HITL control tower simulations is the participation of FAA certified professional controllers (CPCs) from the airport being simulated. Their experience and local knowledge provide the realism and efficiency of operations from the tower that yields accurate and meaningful data and information for managers, planners, and developers.

In most cases, the use of simulations can reduce the risk involved in developing a new airport or modifying an existing airport or its operations, at a fraction of the cost of the proposed changes. The use of real-time HITL simulations is extremely useful for evaluating controller workload and identifying factors affecting airport safety and efficiency. In addition, operational data such as departure rates and taxi times, and pilot-controller communication information such as transmission rate and duration, can be collected and analyzed.

The FutureFlight Central (FFC) facility at NASA Ames Research Center is a full-scale, 360-degree control tower simulator[1]. Real-time HITL simulations are conducted using high-resolution 3D visuals to represent the view from the control tower. A staff of "pseudo-pilots," responding to controller instructions, has operated traffic scenarios at rates upwards of 270 operations (arrivals and departures) per hour. Real-time simulations at FFC offer the unique ability to visualize and control airport traffic for a proposed airport modification long before any concrete is poured, or before any operational changes are implemented.

Why Controllers From Subject Airport are Key to Simulation Success

There are several aspects to a HITL simulation for which the participation of controllers from the subject airport is critical to the success of the simulation. In the development phase, controller participation enhances the accuracy and realism of the traffic samples built for the simulation. Factors such as communications protocol, airfield restrictions, and operational procedures can be addressed with the controllers to insure accurate visuals from the tower, appropriate aircraft movement around the airfield, and realistic communications with the pilots.

The training of personnel involved in the simulation is benefited in two ways by the presence of controllers. Their involvement during scenario training for the pseudo-pilot staff enhances the quality of the training and improves the performance of the pilots during a simulation. In addition, by participating in the actual simulation, the need for controller training is virtually eliminated. Typically, only a short briefing to describe the objectives of the project and any changes to the current airport configuration and/or operations is required, along with familiarization of the FFC tower cab. Training time for the controller staff is reduced from days (for a CPC from another facility), to an hour or two.

During the simulations themselves, the value of utilizing controllers from the subject tower is obvious. They will operate the airport more efficiently and realistically than a visiting controller from another facility, which lends greater validity to audio and surface data collected during the simulation. Their familiarity with the airport allows them to focus on the objectives of the simulation, rather than having to come up to speed on the operation of an unfamiliar airport. In the evaluation of a new Decision Support Tool (DST), the controllers are able to provide very detailed feedback to the developer. Also, by operating realistic traffic samples with proposed operational or airfield changes, controllers are able to identify potential workload and safety concerns to planners and developers.

Simulations That Benefit From Controller Participation

There are several areas where the immersion of CPCs from the subject airport into a real-time simulation yields significant benefits. The first area involves modifications to airport operations. This might include personnel issues, such as reallocating responsibilities for an additional controller position, or airfield issues, such as changing standard taxi routes, modifying runway or taxiway usage, or evaluating proposed regulatory changes.

Another area of importance is the development and evaluation of new decision support tools (DSTs). In the simulation environment, controllers can allow themselves time to learn the new interface, and to utilize and evaluate it in a safe setting. Controllers can provide feedback directly to the developers, yielding a more field-ready product when tested with live traffic.

A unique capability of a HITL simulation, which cannot be duplicated in a live tower setting, is the ability to have controllers operate traffic for proposed airport modifications that do not yet exist at their facility. This may include adding or re-orienting runways and taxiways, adding aircraft terminals, or even moving the control tower itself to a new location. Real-time HITL simulations are the best, if not the only, option for experiencing and evaluating such changes. Radical changes to an existing airport may be thoroughly tested and evaluated by the controllers in a realistic environment.

All of the above situations share the same advantages in having CPCs from the subject airport involved in the simulation. First and foremost is the fact that airport safety and efficiency is not compromised in the simulation environment. In addition, there can be no better operational evaluation provided than that of controllers who work the traffic at that airport every day. Requiring controllers to evaluate a new DST or to test a new operating procedure, while controlling live traffic, increases the potential for mistakes. Also, within the simulation environment, a controller may safely allow himself to become somewhat distracted from the out-the-window traffic in order to focus on simulation objectives. If mistakes are made due to controller involvement in the implementation of a new DST or airport procedure in the simulation environment, no physical risks are incurred. The simulation run may continue, or it may be restarted if appropriate.

Many iterations of a particular traffic sample can be performed in the evaluation or analysis of a new airport procedure or DST. Controllers can be exposed to the same traffic schedule from different positions within the tower. The quantitative surface and audio data obtained during the runs are statistically valid since the data is averaged among several participating controllers over the course of many runs.

Planners, developers, and managers may observe the simulations from inside the tower cab, and controllers can provide valuable and immediate feedback in the form of surveys and debriefs. Any changes suggested by controllers or other observers may be quickly incorporated and re-tested in the simulation environment. These might include operational changes, controller coordination issues, interface or display changes in the case of DST development, or modifications to the airfield itself.

About FutureFlight Central

The unique capabilities of FFC make it ideal for the type of real-time HITL simulation projects that benefit from controller participation. The 360-degree high-resolution 3D visual representation allows an entire airport to be simulated and operated, in all types of weather and lighting conditions. The full-scale tower cab allows all controller positions, including Assist, Supervisor, and Traffic Management Coordinator (TMC) positions to be staffed (Figures 1 and 2). Ramp and TRACON controller positions can be staffed to further enhance the realism of the

Figure 1. FutureFlight Central Tower Cab

control tower operation. All controller and pilot communications can be digitally recorded for playback and analysis. All aircraft movements are recorded, and data is post-processed to provide arrival and departure rates, taxi times, and other quantitative results. Simulations can be replayed with recordings of the pilot/controller communications synchronized with the visual scene. Controllers are able to work under peak airport operating conditions during a simulation. To quote a participating controller from a recent simulation at FFC, “It feels real. Once you start working a problem…you’re into it, you’re working, it’s just like you’re there.” Controllers are able to operate their airport with anticipated future traffic levels and fleet mix, or with modifications such as additional runways, taxiways, or terminals.

Figure 2. FAA Controller Working Position During Recent Simulation

Controller Participation at FutureFlight Central

LAX Runway Incursion Studies

The first major project at FFC involved Los Angeles International Airport (LAX), and the evaluation of several operational and airfield-configuration changes aimed at reducing runway incursions. The studies were conducted in three phases. Phase I, conducted in February 2001, involved the development of a series of baseline scenarios that simulated peak operating conditions at LAX. With the help of a visiting LAX controller, three 45-minute scenarios were developed (VFR peak arrivals, VFR peak departures, and peak IFR operations). The scenarios were run with four LAX controllers in the FFC tower cab controlling traffic. Controllers filled out surveys after each run, rating the scenarios on factors such as traffic complexity, aircraft movement, pilot communication, taxi speeds, and gate-related operations as compared to actual LAX operations. For all of these factors, the scenarios were rated as "sufficiently realistic" or better[2].

Phase II was conducted in April 2001, during which several operational and configuration alternatives were simulated and evaluated. Five alternatives were tested, addressing control tower staffing, runway usage, and a proposed taxiway extension on the south side of the airport to alter runway-crossing operations. Two sets of four LAX controllers participated during Phase II. They adapted quickly to new airport operations as they were introduced, and provided insightful evaluations of the alternatives based on overall safety, efficiency, and manageability of the airport. Surface and audio data were collected and compared with results from Phase I to provide a quantitative analysis of the alternatives[3].

Phase III was conducted in June 2003. A center taxiway concept between runways 25R and 25L was modeled, along with connecting-taxiway and runway modifications to accommodate it[4] (Figure 3). Four LAX controllers participated in the simulation, using their intimate knowledge of the airport to manage significant changes to the south-side operation utilizing the center taxiway. Operational issues were identified, including strategies for holding arriving aircraft between runways 25R and 25L, and coordination between the South Ground and South Local controllers. Armed with this experience, the controllers felt that the concept of the center taxiway could be an effective means for reducing the runway incursion potential at LAX.

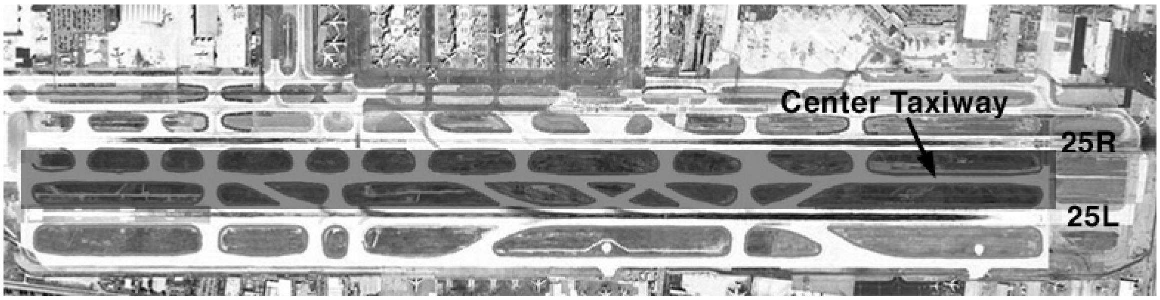

Figure 3. Center Taxiway Concept at LAX International Airport

Without the participation of LAX controllers, little meaningful data would have been available from the simulations. Their expertise in LAX operations and communications provided valid comparison data between the baseline runs and the various alternatives evaluated during Phases II and III. In addition, controllers' feedback during the studies provided valuable information to managers, planners, and developers that were present during the simulations.

Surface Management System (SMS) Development

SMS is an enhanced DST that enables controllers and TMCs to better manage traffic by matching arrival and departure capacity with time-varying airport demands[5]. The purpose of the SMS is to provide decision-support for the planning and use of airport runways, taxiways, and gates. The goal is to increase airport efficiency, while maintaining or improving safety.

Utilizing the industry standard High Level Architecture (HLA) protocol, the SMS was linked to FFC simulation software during two entries in September 2001 and January 2002. The simulations were designed to provide an initial operational assessment of the SMS, and to demonstrate interoperability with another DST, the Traffic Management Advisor (TMA). The TMA is used to assist TRACON and Center TMCs in arrival flow management planning, and is currently in use at the Fort Worth Center. FFC sent data to the SMS via the HLA interface to emulate the radar feeds that an airport-installed SMS would receive. In addition to forecasting runway demand 30 minutes ahead for the tower TMC, the SMS also provides controllers with an enhanced ASDE-X-like display for airport ground traffic, including detailed information tags containing such data as flight number, runway assignment, and taxi instruction.

A staff of five DFW controllers participated in the simulations by directing traffic from the FFC tower cab. They provided feedback on the SMS displays as to their appropriateness and usefulness for the individual controller positions. The east side of DFW airport was utilized as a testbed, and standard DFW operations and runway usage were modified to satisfy the objectives of the simulation. During the second simulation, controllers directed traffic using only information from the SMS display, foregoing the use of flight progress strips (FPS). The controllers indicated that their workload was less using only the SMS than when using only FPS. However, they also identified several important features using FPS that would need to be implemented in a low-workload fashion in SMS before a “strip-less” tower environment could be realized. These issues were addressed, and the SMS has been recently tested with live traffic at Memphis International Airport (MEM).

The involvement of the DFW controllers allowed very difficult scenarios to be conducted efficiently and accurately, providing realistic traffic situations during the SMS evaluation. Their expertise on airfield operations at DFW allowed them to quickly adapt to the modified operations and the new interface, and to provide detailed feedback to the developers as to what additional information and capabilities would be required in order to maximize the accuracy and effectiveness of the SMS in a live tower environment.

DFW Airport Perimeter Taxiway (DAPT) Demonstration

DFW International Airport has proposed the addition of a system of perimeter taxiways at the airport as part of a long-term plan for growth and safety enhancement (Figure 4). These

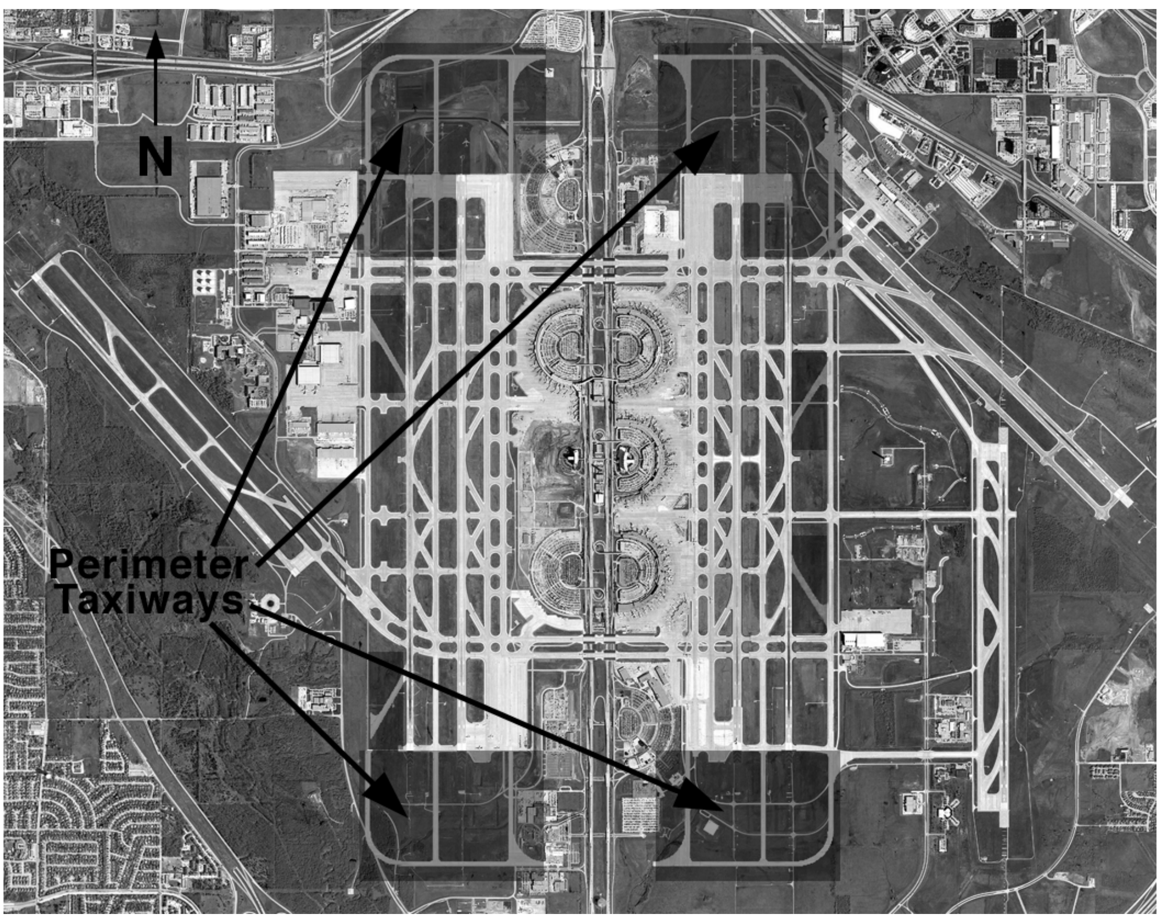

Figure 4. Perimeter Taxiway Concept at DFW International Airport

taxiways would eliminate runway crossings at DFW, of which there are currently approximately 1800 a day. The elimination of runway crossings, especially during peak traffic periods, would improve safety, and would also improve efficiency by significantly reducing arrival and departure delays. The DAPT Demonstration combined several advantages of a real-time HITL simulation: operation of an existing airport with significant changes to the current configuration, a traffic sample with the fleet mix and arrival/departure demand anticipated for the future, and a Boeing 747 cockpit simulator networked to FFC to provide pilot perspectives of the proposed modifications.

A staff of five DFW controllers participated in the four days of simulations. The controllers directed the “future” traffic scenarios from the East Tower perspective, under both the current DFW configuration and operations, and with the perimeter taxiway configuration and associated operational changes. An extremely valuable set of comparison data between the baseline and perimeter taxiway runs were obtained due to the expertise and efficiency of the participating controllers.

For the proposed perimeter taxiway configuration, a third ground-controller position (GE-3) was established. Over the 4-day period, operational guidelines for this position were fine-tuned based on the controllers’ experience during the simulation. Coordination issues with the Ground East-2 (GE-2) controller were identified and resolved. This type of controller involvement can validate a proposed configuration change, or it can serve to point out necessary changes to the design or operations to address traffic management issues that may not be obvious until actually experienced.

Summary

The use of real-time HITL simulations is a powerful tool for evaluating controller workload and identifying traffic and operations factors affecting airport safety and efficiency. In addition, important operational and communications data can be collected and analyzed. The participation of CPCs from the control tower of the airport being simulated is critical to the overall success of the simulation. Their involvement in scenario development, staff training, and the simulations themselves are all key factors in a successful simulation. Their knowledge of operations at the airport, and their efficiency in controlling the traffic, ensures that data collected during the simulations will be of the highest quality. Their feedback to managers, planners, and developers when evaluating new airport layouts, proposed operational changes, or new DSTs is an invaluable source of information. Soliciting the CPC’s involvement in the simulations facilitates the process of reaching consensus on changes to airport operations.

References

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Biography

Mike Madson is a Project Manager for FutureFlight Central at NASA Ames. He has worked at NASA since receiving his B.S. in Aeronautical Engineering from Cal Poly, San Luis Obispo, in 1982. Prior to joining FFC in 2000, he was involved in both computational and experimental aerodynamics research.